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An Interesting Alloeocoel infesting the  
Alimentary Canal of  
*Metacrinus rotundus* P. H. C.

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*With 1 Figure in Text.*

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A number of papers have up to the present appeared with regard to the Rhabdocoelids parasitic of several marine animals, such as Echinoderms, worms, Arthropods and Molluscs. The entoparasitic species previously recorded have been found to infest the alimentary canal, the liver, the kidney and the body cavity. The material serving as basis for the present paper was found lodged in enormous numbers in the alimentary canal of *Metacrinus rotundus* P. H. C., collected in August, 1921, from Nakanoyodomi in the Sagami Sea, at a depth of 150 fms, and was placed in my hand for study through the courtesy of Mr. Yaichiro Okada. At first sight the worms, though a genuine Rhabdocoelid, appeared to be most nearly related to the Trematode chiefly in the possession of a pair of intestinal sacs.

In glancing over a few papers concerning the parasitic Rhabdocoelids<sup>1)</sup> I find some species which inhabit inside, or outside of several forms of the Echinoidea and Holothurioidea. They may be gleaned from the following list.

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1) Graff, L. v., 1882, Monographie der Turbellarien, I. Rhabdocoelida; 1903, Festschr. d. K. Karl-Franzens Univ. in Graz f. d. Jahr 1902; Bronn's Tier-Reichs, Turbellaria, 1904-1908.—Wahl, B., 1906, Sitzs-ber. d. K. Akademie d. Wiss. Math.-nat. Cl., CXV, 417-473.

## 1) Species parasitic of Echinoidea.

*Syndesmis echinorum* François in the alimentary canal of *Strongylocentrotus droebachensis* (Müll.), *St. lividus* Brdt, *Sphaerechinus granularis* A. Ag., *Echinus sphaera* Müll. and *E. acutus* Lam.

*Anoplodium clypeasteris* Graff ectoparasitic (?) of *Clypeaster* sp.  
*Cryptocoelum opacum* Stps. ectoparasitic (?) of *Echinarachnius* sp.  
*Aragina incola* Leiper in the accessory intestine of *Echinocardium cordatum* Gray.

## 2) Species parasitic of Holothurioidea.

*Anoplodium schneideri* C. Semp. in the alimentary canal of *Stychopus variegatus* C. Semp. and *Mülleria lecanora* Jäger.

*Anoplodium myriotrochi* Graff in the alimentary canal of *Myriotrochus rinkii* Steenstr.

*Anoplodium graffi* Montic. in the body cavity of *Holothuria impatiens* Gm.

*Anoplodium parasita* Ant. Schn. in the body cavity of *Holothuria tubulosa* Gm. and *H. polii* Chiaje.

*Anoplodium pusillum* Montic. in the body cavity of *Holothuria polii* Chiaje.

*Anoplodium gracile* Wahl. in the body cavity of *Holothuria forskalii* Chiaje.

*Anoplodium chirodotae* Sabuss. in the body cavity of *Chirodota laevis* O. Fabr.

*Umagilla forskalensis* Wahl. in the alimentary canal of *Holothuria forskalii* Chiaje.

Indeterminable Vorticid in the body cavity of *Cucumaria planici* Marenz.

Reviewing all the species recorded above, the worm herein presented is widely different from any of them in the possession of two intestinal trunks; in fact it is in all probability an Alloecoele, as

will be mentioned later on. Having failed to find any mention of like species in the literature I have come to conclude that it represents a new genus and species, for which a new family may be established. To this I give the name of

*Eicladus metacrini.*

**External characters.**—This new species in the preserved condition has the body of an almost circular, or more rarely oval shape and is of very firm consistency so that it appeared at first sight to be a Myzostoma. Instead of being rounded as is the case with many Rhabdocoels, the body is dorsoventrally flattened, the dorsal surface being slightly convex. The largest specimen measures about 1.5 mm. in length. According to the collector's note taken while the worms were living, the body was of a white colour and wholly devoid of pigments; consequently it revealed the vitelline glands in some yellow streaks which radiate in several directions from near the commencement of the posterior third of the body. In the mature specimens the spacious female atrium is visible from the exterior with more or less distinctness, owing to the presence of some cocoons. No indications of tentacles, eyes and ciliated pits can be demonstrated in the specimens examined.

**Body-wall and Parenchyma.**—Made up of columnar cells in close contact is the epidermis which is in general of a greater height on the ventral than on the dorsal side and is furnished with rather dense but short cilia, a little longer on the former than on the latter. Situated near the base of each epidermal cell is the nucleus which is usually of an oval shape. In the sections available I could not detect any trace of rhabdites and the like. This fact appears, to my mind, to stand in favour of the view that the entire absence of rhabdites may be regarded as a special adaptation in response to the parasitic habit.

Immediately beneath the thin basement membrane, upon which the epidermis rests, comes a delicate muscle layer consisting of two

sets of fibres, the circular and the longitudinal, of which the latter are much more poorly developed as compared with the former. As is usual, the musculature vary somewhat in thickness, being much thicker on the ventral than on the dorsal side. Dorsoventral muscles are well developed in several parts of the body. In addition to these, numerous fine muscles are found in the parenchyma around several internal organs.

So much space in the body is taken up by several internal organs, that the parenchyma is very much reduced. The parenchyma presents different aspects in different parts of the body. In the outer portion it is of a somewhat cellular nature, as is the case with most parasitic forms. The cells are large vesicles which have usually a distinct membrane and contain a nucleus. The protoplasm is seen to present an alveolar appearance, much as in *Fecampia xanthocephala* Caull.-Mesn. In the inner portion the parenchyma appears to be partly of a fibrous nature.

Below the dermal musculature, in the parenchyma, are found numerous gland cells, which are stained deeply in the carmine dyes and occur scattered on both sides. Processes from these cells pierce the basement membrane and make their way through the epidermis to the surface. The cells are much more abundant on the ventral than on the dorsal side.

**Digestive Organs.**—Near the commencement of the second quarter of the body lies the mouth opening which leads into the narrow pharyngeal cavity with the direct wall composed of high columnar cells. The cavity is continued upward into the small pharynx which is of a bulbous type, instead of a plicatus. The pharynx is entirely separated from the surrounding parenchymatous tissue by a muscle layer. Its direct walls are an epithelium of high columnar cells, which is coated by a sheath of parenchymatous tissue traversed cross-wise by muscle fibres. Besides these radial fibres, the musculature of the pharynx consists of two sets of fibres, the internal and the

external, of which the latter are arranged so as to bound the pharynx from the surrounding parenchyma in association with some longitudinal fibres.

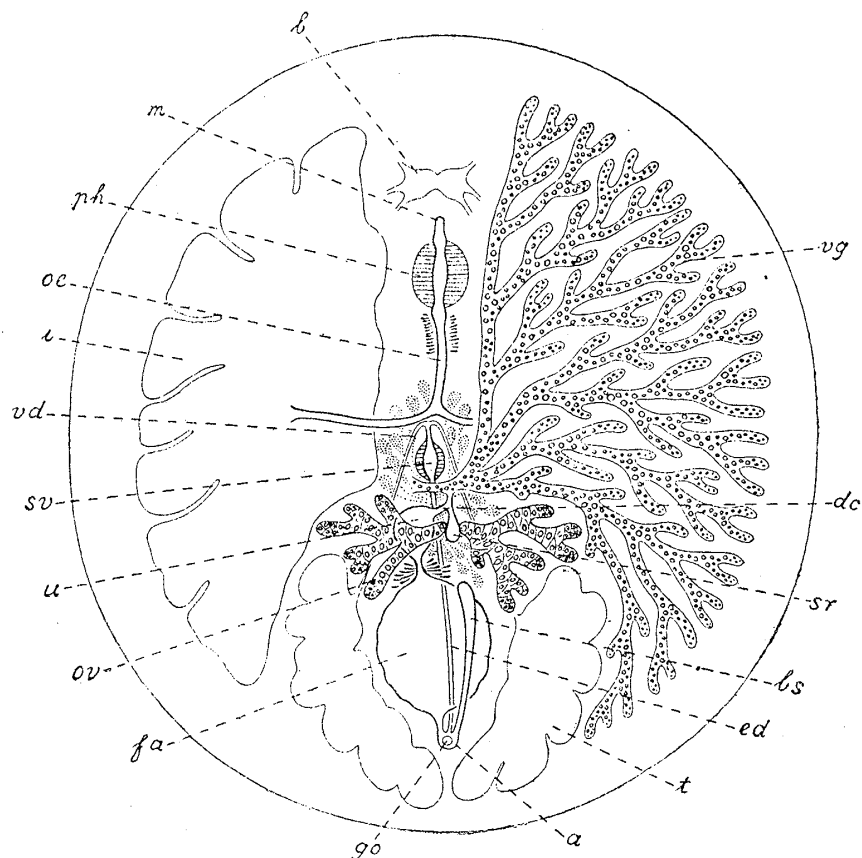
Posteriorly the pharynx is continuous with a slender oesophageal canal, which is lined by an epithelium of columnar cells and is supplied for a short distance behind the pharynx with numerous gland cells embedded in the surrounding parenchyma. After extending as far back as the level of the middle of the body, the canal, differing from the condition found in most Rhabdocoels, divides into the branches which stand in communication with the intestine, having a great extension on each side and sending out some laterally directed diverticulae. This looks as if the intestine in such a form as *Solenopharynx oculatus* (Pereyasl) is longitudinally splitted in association with a part of the pharyngeal canal. *S. oculatus* is characterized by the possession of a long pharyngeal canal which leads into a simple intestinal sac. To judge from the bifurcation of the alimentary canal, the present species appears to afford some alliance to the Trematodes in general. The direct walls of the intestine are quite different in construction from that of the oesophageal canal, consisting, as it does, of large columnar cells, which appear to be all similar to one another. Occasionally they are found vacuolated or contained some globules at the distal portion.

**Excretory Canals.**—In hardened specimens and in sections I have looked for the excretory system in vain. As is the case with some parasitic forms, it may be very much reduced in accordance with a parasitic mode of life.

**Nervous System.**—Slightly in front of the pharynx occurs the brain which is a mass of finely fibrillated material which, on its dorsal aspect, sends out the roots of the nerve trunks on each side. Surrounding the fibrillated material of the brain are nerve cells which are most abundant over the dorsal portion.

So far as my observations go, the nerve trunks are three pairs in

number, the anterior, the middle and the posterior, which give off numerous branches subdividing and anastomosing to form a plexus.



Diagrammatic figure of *Bicladius metacurini* nov. gen. et sp., as seen from the dorsal side. *a* antrum, *b* brain, *bs* bursa seminalis, *dc* ductus communis, *ed* ejaculatory duct, *fa* female atrium, *go* genital opening, *i* intestine, *m* mouth opening, *oe* oesophagus, *ov* ovary, *ph* pharynx, *sr* seminal receptacle, *sv* seminal vesicle, *t* testis, *u* uterus, *vd* vas deferens, *vg* vitelline gland.

**Reproductive System.**—The common genital aperture is placed near the commencement of the posterior one-sixth of the body, leading into a narrow antrum. Anteriorly the antrum stands in communication with the spacious female atrium through a canal, and dorsally it continues into the bursa seminalis. Between these the antrum receives the opening of the ejaculatory duct from the front. The direct walls of the antrum are made up of high columnar cells.

**Male Organs.**—The testes are large lobed compact bodies which possess a well-marked membrana propria and lies on either side in the posterior third of the body. They are found contained sperm-cells in several stages of development. From the antero-median part of each testis arises the seminal canal which, though unable to ascertain with enough certainty, proceeds in an anterior direction and unites with its fellow of the opposite side into a single canal. Not far behind the mouth the canal abruptly turns backward to open into an ovoid vesicle, the seminal vesicle, which is placed ventrally just in front of, or lateral to the female organs. The vesicle is of moderately large size and has the thick wall of a muscular nature. The musculature consists of two sets of fibres, the inner circular and the outer longitudinal. Posteriorly the vesicle gives rise to a slender canal, the ejaculatory duct, which runs backward, passing ventral to the genital atrium, and opens into the antrum. No organ comparable with the penis is present. Ejaculation may in all probability be effected by the great contractility of the muscular wall of the seminal vesicle.

**Female Organs.**—The ovaries are represented by some branching cords of egg-cells, placed on each side just in front of, or mediad to the testis and surrounded by a membrana propria, in some parts of which there can be observed some pigment granules. The generative zone of the ovary is usually placed at near the distal end and contains a number of small cells. In the fully grown specimens the mature ova are found to occur in the most part of the ovaries. They are of large size and contain a large vesicular nucleus with a spherical nucleolus, which is eccentrically placed. Scattered in between the ova are the nuclei which may be considered as those of rudimentary egg cells, at whose expense the ova develop.

The vitelline glands are branching cell-cords, extensively distributed ventrally on each side of the body. Near the commencement of the posterior third they converge to unite with one another. In the fully developed condition, each vitelline cell is of large size and

contains, exclusive of a small ovoid nucleus placed near the centre, a few moderately large homogeneous and highly refractive globules of an olive colour in the protoplasm. Probably they may furnish not only the necessary nutriment for the embryo but also the substance of the cocoon capsule.

Placed in several parts, especially near the distal ends of the vitelline cell-cords is the generative zone, which is characterized by small, closely apposed, polygonal cells, each containing a nucleus of an almost spherical shape. From this period onward, the development and the metabolism of a certain substance appear under the microscope as the most striking activities of the tissue. In the protoplasm there can be at first observed typically a small homogeneous, highly refractive globule of an olive-like colour and generally some smaller ones. The larger globule increases in diameter, at first more rapidly than the cell containing it, compressing the nucleus to a certain degree as it enlarges. With the development of the cell-body the outer smaller globules alternately enlarge to spherical ones of nearly similar size and proceed to the final stage of development. At length they become arranged to lie well toward the periphery of the cell and generally to surround the nucleus. The ectoplasmic matrix is replaced by the growing globules until a plasma slightly remains between the latter and the nucleus. The cells become loosened from each other, and round up from a polygonal to a spherical form.

The female atrium is extremely spacious, irregular in contour and occupies a position in the posterior third of the body. Its direct walls are a thin epithelium beneath which comes a thin layer of interlacing muscle fibres. In some specimens there are found some cocoons in its lumen. Anteriorly the cavity is communicated with a smaller one, the so-called uterus, through a short and narrow canal. Near the communication of the canal with the spacious atrium, in the parenchyma, there exist numerous gland cells, the secretions of which it receives. The uterus has the wall constructed on the same plan as



observed in the atrium and is regarded as representing an organ, where the formation of the cocoon takes place. I was fortunate enough to meet with an example possessing a cocoon in the lumen of the organ. The organ, on its anterodorsal aspect, gives rise to a short canal which is lined by an epithelium of cubic cells and receives the secretions of numerous shell-glands occurring widely distributed in the parenchyma. The canal may be called the ductus communis. At the end the duct, after receiving the communication of the vitelline glands from the front, is continued into a very short canal ending in a swelling, which is seen to be in contact with the ovaries. In many cases the spermatozoa are found filling the swollen part. This fact appears to be in favour of the view that the swollen part has function in connexion with the seminal receptacle. It is beyond doubt within its lumen that fertilization takes place.

The connexion of the vitelline glands with the ductus communis is a secondary one; it takes place at the distal end. So far as my observations go, the vitelline glands are seen to stand in direct connexion with the duct. The mode of connexion of the ovaries could not be definitely made out in the sections available.

The canal, leading from the antrum and passing dorsal to the female atrium, probably represents the bursa seminalis, which is observed filled with spermatozoa.

**On the Formation of the Cocoon.**—As is well known, the ova are in the Rhabdocoelids enclosed within a protecting case, the cocoon capsule, which contains also a quantity of yolk cells derived from the vitelline glands. With regard to the formation of the cocoon capsule some different views have up to the present been put forward by several authorities. Luther<sup>1)</sup> and some others assumed its formation in the ductus communis, ascribing the source of the capsule to the shell-glands opening into the organ, and that it makes its way into the uterus.

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1) Zeitschr. f. wiss. Zool., LXXVII (1904), 128, 129.

In some specimens I have found a cocoon which fills up the cavity of the so-called uterus following the ductus communis. Beyond doubt it had been formed in the organ. Apparently differing from the condition found in the Tricladids which have in general the capsule of a finely granular nature, the capsule of this species is very thin and presents an olive coloured, homogeneous appearance as the same as some globules found near the periphery and undoubtedly derived from the vitelline glands. I feel it better to regard that the substance of the cocoon capsule is partly produced from the vitelline cells, as stated by Burr<sup>1)</sup> in the case of the Tricladids. Of course, the secretory product of the shell-glands seem to play an important part in the formation of the cocoon capsule.

The cocoon after being formed makes its way into the atrium. The ova enclosed within the cocoon are of a moderately large spherical form and possess a large nucleus with a nucleolus, which is eccentrically placed. As compared with the vesicular state in the ovarian egg, the nucleus of the ova has a comparatively dense appearance, and takes the colour much deeper than the protoplasm, which is very finely granular. The vitelline-cells occurring in association with the ova are of small size, spherical in form and possess a small nucleus. In no case have I been able to observe any trace of globules.

**Systematic position.**—Clear as it may appear from the above account, the present species, in some features of its organization, is most nearly related to the Trematodes. In the worm in question the canal which leads from the posterior end of the pharynx divides, as before mentioned, into two branches, which, instead of running almost parallel, as far as the hinder end of the body, communicate, each separately, with the lobed intestinal trunk on either side. This state of things, though different in the strict sense, is somewhat similar to what we find in the Trematodes, exclusive of some Gasterostomes, in which the intestine is a simple sac, much as in the majority of the

1) Zool. Jahrb, Abtg. f. Syst., Geogr. u. Biol., XXXIII (1912), 595-636.

Rhabdocoelids. The similarity is also true of some Monostomes, Distomes and Amphistomes in the young, or even in the adult condition. In the possession of a ciliated epidermis as well as in the absence of any trace of sucker, however, the present worm widely differs from the Trematodes. Save in some exceptional cases (*Pronopharynx*), which are devoid of adhesive sucker, they are generally furnished with one or more well developed suckers.

As may be seen from the above, the connexion between the Turbellaria and the Monogenetic Trematodes is very close—so much so that it is difficult to give any characters of universal occurrence distinguishing all the members of the two classes. To me it seems very likely that the Trematodes may be polyphyletic group, their different families probably having become, as stated by some authorities, developed from different groups of Turbellaria altogether independently. Some of them appear certainly to be nearer the Rhabdocoelids.

In spite of the entire absence of sucker the worm in question is also closely related to the Temnocephalae, their digestive and genital organs being constructed on similar plan. As is well known, the latter possess an epidermis partly ciliated and a simple undivided intestinal sac. The sucker, present in the Turbellarians only in some of the Polyclads and a few Triclad, is entirely absent even in the parasitic Rhabdocoelids. In this respect the present worm stands distinctly at variance with the Temnocephalae, which are characterised by the possession of a row of adhesive tentacles at the anterior end as well as of a true sucker near the posterior extremity of the body.

Temnocephala when first discovered was referred by Gray to *Branchiobdella*, a Hirudinean genus. However, it was dealt by Philippi<sup>1)</sup> with a form which ought to be placed among the worms in the neighbourhood of *Malacobdella*, and then considered by Carl Semper<sup>2)</sup>,

1) Arch. f. Naturgesch., 1870.

2) Zeitschr. f. wiss. Zool., XXII (1872), 307-310.

Haswell<sup>1)</sup> and some others as affording a close affinity with the ectoparasitic Trematodes much more than with *Malacobdella* or the Hirudinea and as connecting links between the Turbellaria and Trematoda. Its systematic position, however, is still open to question.

Judging from the above account, it may, I feel, be advisable to deal with the worm in question as representing a member of the alloecoel Turbellaria.

With our present knowledge of the Alloecoels it is extremely difficult to make out the relationship of the present new genus. On revision the Alloecoels recorded hitherto are found divided into three section—Holocoela, Crossocoela and Cyclocoela—, chiefly making use of the different features of the intestine. In the Holocoela the pharynx is of the valiabilis type, leading into the simple intestinal sac without lateral diverticulae. In the other two sections the intestine is in general divided by the pharynx of the plicatus type into pre- and post-pharyngeal trunks which usually send out lateral diverticulae. In particular the worms belonging to the Cyclocoela are provided with the intestine of the Triclad type; consequently they may be regarded as presenting a close affinity with the Triclads. In the literature I have failed to find any mention of species with the alimentary canal constructed in similar manner to that we find in the majority of the Trematodes. Hence I am inclined to institute a distinct family for receiving the present genus.

In conclusion I gladly seize the opportunity of thanking Marquis Yoshichika Tokugawa for providing me with accommodation in his Biological Institute, where the present investigation was prosecuted.

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1) Quart.Jour. micr. Sci., XXVIII (1888), 279-302.